Near-surface Measurements In Support of Electromagnetic Wave Propagation Study

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Award # N0001413WX21166

LONG-TERM GOAL

The long-term goal of this project is to improve environmental prediction for electromagnetic wave propagation forecast.

OBJECTIVES

The objectives of this project are 1) to characterize atmospheric conditions resulting in nonstandard EM propagation in the atmospheric boundary layer during Trident Warrior 2013 field campaign; 2) to support NPS ongoing research on numerical simulations of EM propagation using AREPS and COAMPS single column model.

APPROACH

Basic approaches of the project involves measurements of the NPS Marine-Air-Sea Flux (MASFlux) buoy during Trident Warrior 2013 (TW13) field campaign and analyses of the measurements to reveal the interplay between surface fluxes, surface layer mean profiles, surface waves, and upper ocean temperature. This analyses will be aided by other measurements from TW13 including rawinsonde profiles and measurements from other platforms.

The TW13 data will be used to initialize/evaluate planned COAMPS single column model simulations in an effort to improve predictions of the near surface thermodynamic profiles as input to EM propagation modeling.

Qing Wang is responsible for the overall project and part of the TW13 data analyses. NPS Ph. D student, LCDR Corey Cherrett, will make more in-depth data analyses. Mr. Dick Lind was responsible for buoy preparation and field deployment.

WORK COMPLETED

1. Completion of the Trident Warrior 2013 field experiment in July 2013. NPS team was involved in flux buoy deployment, real time AREPS simulation, rawinsonde launches, and kite-based measurements (Peter Guest). Real-time data QC and analyses were made to support EM modeling and sampling efforts in addition to UAV operation.

Report Documentation Page

Form Approved
OMB No. 0704-0188

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1. REPORT DATE **30 SEP 2013**	2. REPORT TYPE	3. DATES COVERED **00-00-2013 to 00-00-2013**
4. TITLE AND SUBTITLE **Near-surface Measurements In Support of Electromagnetic Wave Propagation Study**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Postgraduate School,Department of Meteorology,Monterey,CA,93943**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**6**	

2. Preliminary data analyses on NPS buoy measurements as well as rawinsonde measurements made by NPS (Peter Guest) and NSWC (Kate Horgan). These analyses involves data QC efforts as well as efforts to understand the general EM propagation conditions during the TW13 field campaign.
3. Participated in the TW13 workshop and presented initial results of NPS buoy measurements. Also participated in group discussions for plans of future collaborative work.

RESULTS

TW13 NPS measurements overview: During TW13, NPS made extensive measurements with flux buoys, rawinsondes, and shipboard instruments. Figure 1 summarizes the time periods of these measurements together with all rawinsonde soundings and kite soundings made by NSWC (Kate Horgan) and NPS (Peter Guest). Three periods of buoy measurements were made on July 14, 15, and 16, respectively. The locations of the soundings and buoy measurements are given in Figure 2. The measurements on July 14 and 16 were very close to the coast of Virginia Beach, while the flux buoy was about 50 km offshore on July 15. Figure 3 shows the variations of four levels of temperature measurements near the surface and three levels in the water on all three days. The surface layers on these three days had rather different thermal stratifications with July 14 and 16 having weakly stable and stable conditions, and July 15 having offshore unstable conditions. The table insert shown in Figure 3 summaries the air-sea temperature difference from all three periods of measurements to quantify the sign and magnitude of the thermo stability. It is also seen from all subplots of Figure 3 that strong temporal variability was observed on each time period, especially on July 14 and 16, both measurements were made close to the coast. Such observed temporal variation is likely a combination of temporal and spatial variation as the buoy was also drifting with the current, particularly on July 16. Our future analyses will examine how this temporal and spatial variability may affect the surface flux parameterization.

Near-surface vertical profiles and deviation from Monin-Obukhov similarity: Measurements from the NPS flux buoy provided an unique opportunity for examining the vertical profiles of temperature, humidity, and wind within several meters of the sea surface. Figure 4 shows the hourly averaged near-surface profiles from 15 July, 2013 with unstable thermal stratification in the offshore region. The potential temperature profile and the top water temperature profiles are plotted on the same figure to illustrate the coupled evolution on both sides of the interface. We can clearly see the atmospheric adjustment to the changing water temperature from the evolution of both air and water temperature. The largest gradient between the warm sea and the relatively cold air appear to be below 0.38 m above surface, which is the lowest level of temperature measurements on the buoy mast. We also find that the thermo stability appears to be similar between 0.38 m and 1.54 m, but further decrease above 1.54 m. Figure 4b shows the wind speed variability with height. Three of the profiles (one-hour average centered at 15:16, 16:16, 17:16 UTC time) show signs of wind reversal, where the wind speed at 1.8 m is higher than that from 3.5 m, a clear deviation from the log-wind profile or its variations in stability affected conditions. The evolution of the moisture profiles in specific humidity and relative humidity are shown in Figure 4c and 4d. The strong temporal/spatial variability shown here will be 'blended' with the measurements from higher above to provide a full profile for further evaluation of their impact on EM propagation.

IMPACT/APPLICATIONS

Near-surface temperature and water vapor variability are crucial to EM propagation close to the surface and yet is normally not directly sampled from in situ measurements. The NPS MASFlux buoy has the unique capability that provides concurrent measurements of both near-surface profiles and the surface momentum flux. With further analyses, this dataset should provide more insights on the flux-profile relationship in the lowest several meters over the ocean and insights on flux parameterization in complex coastal regions.

RELATED PROJECTS

Related project is the ONR Trident Warrior 2013 exercise.

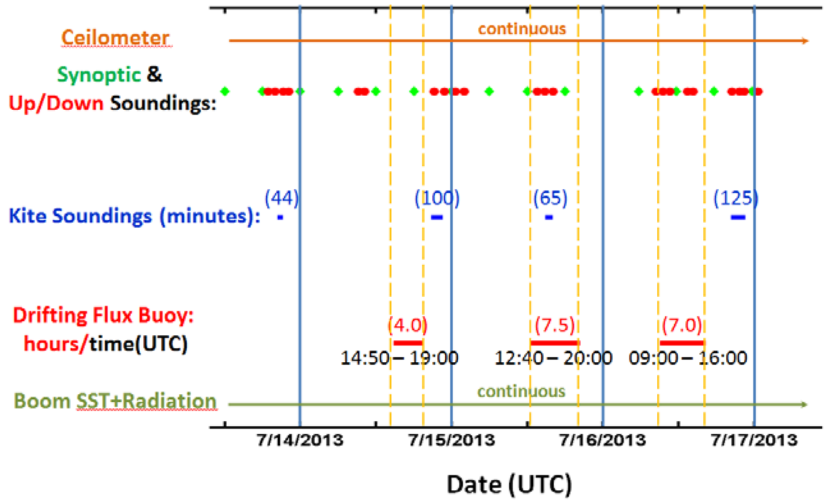


Figure 1. Timeline of all NPS-related TW13 measurements from the R/V Knorr between 14-20 July, 2013.

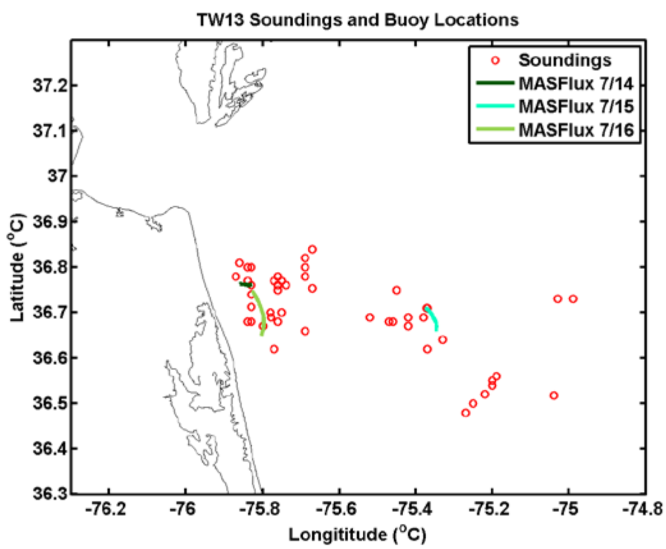
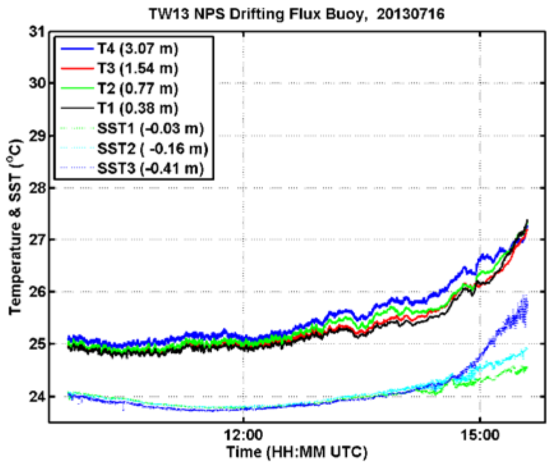
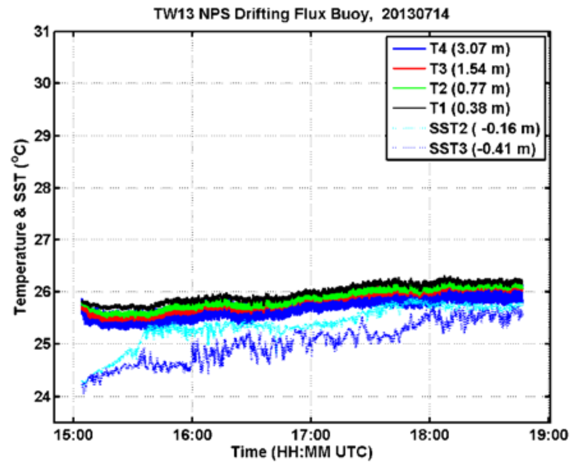
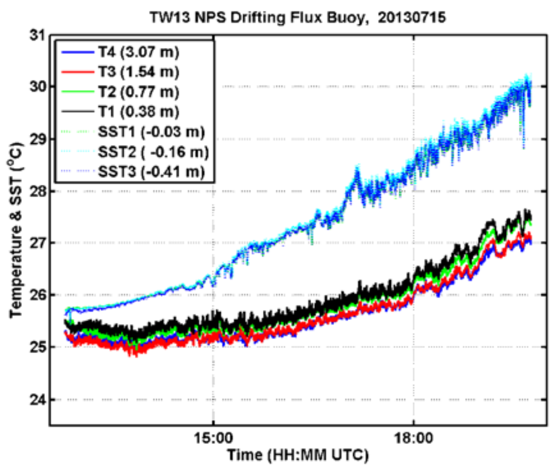


Figure 2. Locations of all soundings and NPS MASFlux buoy during TW13.







Date	SST	T-air	Δ(SST-air)
7/14/2013	25.4	26	-0.61
7/15/2013	27.4	25.9	1.47
7/16/2013	24	25.3	-1.28

Figure 3. Variation of air and top water temperature from the three measurement periods of MASFlux during TW13. The table insert give a summary of the mean SST from the top water sensor at ~3 cm below surface and the mean air temperature from the lowest sensor at 0.38 m above water line.

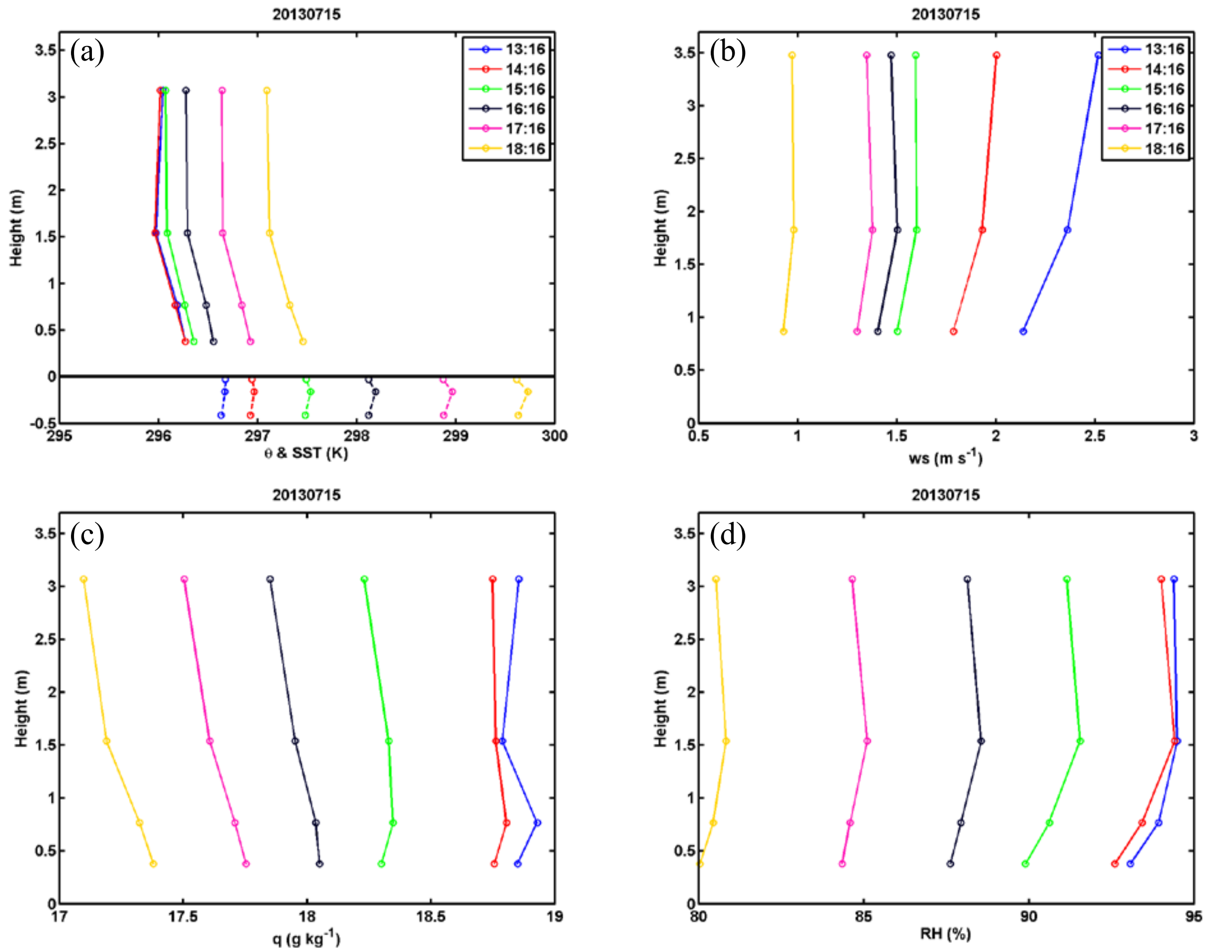


Figure 4. Hourly averaged near-surface profiles of (a) potential temperature and water temperature; (b) wind speed; (c) specific humidity; and (d) relative humidity. The legend shows the middle of the hour-long period during which the averages were made.